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MORE ON INSURANCE AND CATASTROPHIC EVENTS: CAN WE EXPECT DE FAC--ETC(U)

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MORE ON INSURANCE AND CATASTROPHIC EVENTS: CAN WE EXPECT DE FACTO LIMITS ON LIABILITY RECOVERIES?

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PREFACE

This paper surveys the subject of de facto recovery limits due to catastrophic events. It was presented at the American Nuclear Society Topical Meeting on Probabilistic Analysis of Nuclear Reactor Safety in May 1978.

SUMMARY

The purpose of this study is to take an overview of large technological systems in society to ascertain the prevalance, if any, of situations that can lead to catastrophic effects where the resultant liabilities far exceed the insurances or assets subject to suit in court, thereby imposing de facto limits on liability recoveries. In part, interest in this topic is spurred by the continuing discussion and controversy over the Price-Anderson Act which requires operators of nuclear plants to waive certain defenses and which limits the combined liability of the operator and the government to an amount less than the maximum potential public cost of a major nuclear reactor accident.

A variety of technological events could result in assignable liabilities up to $25 billion, or more, depending on the value of life. These postulated events include:

(1) The crash of a large aircraft into a crowded sports facility (an estimated $20.3 billion liability);
(2) An explosion and subsequent dispersion of a chemical (such as chlorine or LNG) into a population center from a large manufacturing, storage, or transport facility (estimated $25.5 billion liability);
(3) A massive nuclear power plant accident and the subsequent dispersal of large quantities of radioactive material to a large downwind population center ($25 billion liability);
(4) The collision of two ships, such as a large LNG tanker and a large passenger liner, resulting in the deaths of all passengers on board ($5.5 billion liability); and
(5) Collapse of a large building in an earthquake, known by the owners to be seismically deficient and no steps having been taken to warn occupants or to remedy the situation (major deficiencies).

All these events are found to involve potential liability far exceeding the available resources, whether they be insurance, corporation assets, or the annual budget of the Federal Disaster Assistance Administration.

A postulated event that is most likely to greatly exceed the de facto limit on liability recovery is a gross dam rupture and the subsequent drowning of tens or hundreds of thousands of people, plus great property damage.

Some of the hypothetical events, such as a large train disaster, may not have costs which exceed the insurance and attachable assets. However, a variety of questions remain to be considered with regard to the actual availability of corporate assets for compensation, including the following:

- What fraction of the assets of a corporation would a court permit to be assigned to pay a winning damage suit, keeping in mind the effect on "innocent" stockholders, etc. If $200,000 per life completely used up all the assets, would such an award be made?
- Are the assets, as listed, actually available dollar for dollar, to cover liability from a major accident?
- What would the injured parties or their survivors have to prove to collect for their loss in a low-probability event which results from forces beyond normal engineering design requirements?

All in all, the matter is quite complex. Liability limits, whether by law or de facto in nature, appear to be prevalent in society. They represent a problem which should be attacked in some coordinated way, including other issues that have been raised, such as the possible loss of incentive for improved safety.

Introduction

In anticipation of and in response to increasing public awareness of risks from technological activities, a loosely organized literature has formed to deal with the issue "How safe is safe enough?" This field, generally referred to as risk analysis, deals with a wide variety of topics relating to risk-taking including the apparent relationship between benefits and risk, the distinction between perceived and statistical risk, the treatment of low probability - high magnitude risk events, the effect of uncertainty in risk measurements, and distributional effects of risk in space and time.

Much of the incentive for this work comes (as do many of the researchers) from the nuclear power field, although there is now significant cooperation and cross-fertilization with researchers in the areas of chemical and pharmaceutical safety, transportation safety, and fire safety. A feature common to all these areas is the need to balance public safety with the costs to society of risk control. In the past, regulations in these areas were frequently established subjectively, with standards arrived at by a trial and error process. A shift to more analytically based criteria is now occurring, and several attempts to use risk analysis to define safety criteria are now in progress.

One aspect of risk management that directly impacts the damages borne by society are the mechanisms by which risk is distributed. While not actually changing the probabilities associated with various types of physical events, insurance provides a means for distributing the financial loss associated with these events.

References to insurance mechanisms are infrequently found in the risk analysis literature, with the exception of the method of insuring nuclear power plants (with procedures defined by the 1957 Price-Anderson Act). In part, this lack of information stems from the difficulties in obtaining information on the amount of insurance carried by operators of large facilities capable of producing catastrophic damages; in part it is due to the fortunate lack of truly catastrophic accidents in the United States in recent years. While we have been able to obtain some information about the amounts of insurance carried by some companies, no definitive reference for these figures is available, and in all cases these amounts were obtained in a "don't quote me" conversation, and are therefore somewhat questionable.

In this paper we describe the various mechanisms through which large liability insurance is obtained, and compare the estimated maximum damages of certain accidents with the amount of insurance carried. Beyond this, we examine the assets available to provide for damages beyond these liability policies. We also discuss the methods by which the injured parties can collect for their damages.

In large part, this paper is a synthesis of two previous papers: "Insurance of Nuclear Power Plants", by Chris Whipple, June, 1976,[(1)] and "Catastrophic Events Leading to De Facto Limits on Liability" by Kenneth Solomon and David Okrent, UCLA School of Engineering and Applied Science report UCLA-ENG-7732, May 1977.[(2)*] (Also published by the Rand Corporation under the title "Some Comments on De Facto Limits on Liability", June, 1977[(3)].)

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Insurance Under the Price-Anderson Act

The Price-Anderson Act, which establishes procedures for insuring nuclear power plants, has been a frequent target of criticism since its passage in 1957. Evaluation of the specific criticisms and arguments in rebuttal to these criticisms suggests that an examination of the systems through which liability damages are provided in other technical activities with extremely high potential losses can provide an appropriate background against which this insurance method can be evaluated. Through this examination, little difference is detectable between the protection (and lack of protection) afforded the public through Price-Anderson and that provided by the more common insurance methods.

The uncommon (but not unique) features of nuclear power plant insurance are:(4)

1. The reactor operator is strictly liable for damages regardless of cause. He has agreed to waive the use of a defense that argues that he was not negligent, that the claimants implicitly or explicitly accepted the risk, that they contributed to the accident by their own negligence, that the cause was due to acts of God, or that the statute of limitations has expired. The operator can deny a causal chain between the accident and the claimants' losses.

2. The operator assumes all public liability arising out of an accident, including that which might fall upon the manufacturers of the plant or its equipment.

3. Under the original mechanisms of the Price-Anderson Act, the aggregate liability of the operator, the NRC, and others who might be at fault is limited to $560 million. Lawsuits against the reactor owner or manufacturer in excess of this amount are prohibited. This provision (the most controversial of the Price-Anderson Act) provides that should damages exceed $560 million, the claimants would divide the available $560 million on a prorated basis. The act further provides (in its 1975 renewal)(5)

> "That in the event of a nuclear incident involving damages in excess of that amount of aggregate liability, the Congress will thoroughly review the particular incident and will take whatever action is deemed necessary and appropriate to protect the public from the consequences of a disaster of such magnitude..."

4. The mechanism by which coverage for the $560 million liability is obtained has recently been changed. Originally, the reactor operator was required to purchase as much conventional liability as was available from private sources, and purchase the additional amount necessary to reach $560 million coverage from the government. This has since been modified to include a layer of insurance coverage above that privately available (but below that sold by the government) through assessments of all reactor operators in the event of an accident which exceeds the privately available insurance.(6) These assessments would be between $2 million and $5 million per reactor; this currently would provide coverage of between $130 million and $325 million, and would therefore lessen the amount of

insurance sold by the government. The aggregate liability would remain at $560 million until the total coverage provided by private insurance and retroactive assessments exceeds this amount, at which point the liability limit would rise to the sum of these two amounts. Currently, $140 million of nuclear reactor liability is available through the private insurance markets; the amount available has been rising steadily from the initial $60 million available in 1957.

In April 1977, the Price-Anderson Act was ruled unconstitutional in U.S. District Court. This ruling has been appealed.[7]

Liability Insurance for Other Activities

The Price-Anderson Act specifies methods of insuring nuclear power plants (and other nuclear facilities) that are quite different from the liability insurance methods used for other facilities. The two principal differences are that no statutory limits on liability apply and that a no-fault type of insurance is not used. This means that the liability exposure to the operator is unlimited; in a practical sense the ability to pay damages is limited to the amount of insurance carried plus the assets of the operator of the facility. A person injured by an accident is required to prove the culpability of the operator of the facility - in these cases defenses are not waived. In the past, acts of God relieved the operator of responsibility for accidents (provided the facility met appropriate building and safety codes, and was not operated in a negligent manner). This inter-

pretation has changed in recent years; operators are frequently (but not always) found liable even under these circumstances.

A direct comparison of the insurance costs and amounts for nuclear and non-nuclear facilities would be extremely interesting; however companies that operate facilities capable of incurring large liabilities (such as those owning dams, airplanes, refineries, or chemical plants) usually do not insure on a plant-by-plant basis but carry "umbrella" coverage. (Umbrella coverage provides protection against any accident claim for which the company might be found liable.)

Maximum-Consequence Events

(Authors note: this section is taken directly from reference 3 with only minor changes.)

High consequence accidents have been considered arising from a number of causes (see Table 1), both natural and man-made. For all events and accidents listed in this table, we have provided an estimate for the maximum accident in two different ways. In one instance we identified the largest-consequence accident that has already occurred, or something with the same order of magnitude. In the second instance we identify events similar to the largest consequence that might be postulated. Neither of these approaches guarantees that we have identified the actual largest-consequence event that could ever occur for either of the scenarios, nor is there any need to do so for purposes of this study.

TABLE 1'. ESTIMATED LIABILITIES ASSOCIATED WITH HIGH-CONSEQUENCE RISKS

EVENT AND/OR ACCIDENT SCENARIO	ACTUAL, HISTORICAL WORST-CONSEQUENCE EVENT			POSTULATED, WORST-CONSEQUENCE EVENT[a]		
	Date, Location, Description	Number of Fatalities (Actual Number)	Estimated Liability if occurred today[b] ($ Billion)	Estimated Probability (per year)	Estimated Number of Fatalities or Complete Disabilities	Estimated Liability[b] ($ Billion)
AIRCRAFT CRASH[c]	3/29/77; Canary Islands (Spain); two 747's in ground collision	577	0.65	$1x10^{-5}$ to $1x10^{-7}$ for a selected site adjacent to a selected airport	6,000 to 20,000	6.3 to 20.3
CHEMICAL EXPLOSION & FIRE[d]	12/6/17; Halifax, Canada	1,600	1.8	10^{-5} to 10^{-7} per site	12,000 to 25,000	12.5 to 25.5
DAM RUPTURE[e]	9/9/63; Vaiont, Italy	1,800	2.0	$1x10^{-3}$ to 10^{-4} per site for high risk sites	20,000 to 750,000	20 to 800
DRUG TOXICITY[f]	Thalidomide Post World-War II	Hundreds of badly deformed babies	~0.5	10^{-4} to 10^{-6}	(?) 10,000 to 100,000	(?) 10 to 100
EARTHQUAKE[g]	12/24/1556; Shensi, China	830,000	830	$1x10^{-3}$ to $1x10^{-4}$	100,000 to 1,000,000	100 to 1,000
FIRE[h]	9/9/1871; Peshtigo, Wisc; forest fire	1,182	1.5	$1x10^{-6}$ per high risk site	1,000 to 3,000	1.1 to 3.2
FLOOD[i]	1897 Hwang-Lo River China	900,000	1,000	$1x10^{-2}$	200,000 to 1,000,000	200 to 1,000
METEORITE IMPACT[j]		No known mortalities	No large liabilities	$1x10^{-7}$	10,000 on up	10 to 12
MINE DISASTER[k]	12/6/1907; Monongah, West Virginia	361	0.36	$1x10^{-2}$ to $1x10^{-3}$	500 to 1,000	0.5 to 1.0
NUCLEAR REACTOR ACCIDENT[l]	—	No known mortalities in civil program	—	$1x10^{-7}$ for high risk site	10,000 to 20,000	15 to 25
SHIP DISASTER[m]	4/5/12; North Atlantic Ocean, Titanic hit iceberg	1517	1.7	$1x10^{-6}$ to $5x10^{-7}$	2,500 to 5,000	2.8 to 5.5
TIDAL WAVE/ HURRICANE[n]	Several during 1963-65 in windstorm, E. Pakistan	79,000	80	$1x10^{-2}$ to $1x10^{-3}$	50,000 to 500,000	55 to 520
TORNADO[o]	3/18/25; in states of Mo., Ill., and Ind.	689	0.75	$1x10^{-2}$ to $1x10^{-3}$	1,000 to 10,000	1.2 to 10.3
TRAIN CRASH[p]	12/12/17; France	543	0.60	$1x10^{-1}$ to $1x10^{-2}$	200 to 2,000	0.22 to 1.1
INDUSTRIAL POLLUTANT[q]	Pre-1970; Mercury poisoning Miramota, Japan			10^{-4}	~10,000	10

Footnotes to Table 1

(a) This refers to the "maximum credible accident" (MCA), which is a single risk point, not the integral of all risk events.

(b) These estimates are based on the assumption that the value of life is $1 million. Property damages are also considered. The estimates are high for historical events, but may be more realistic for recent and projected events. They are based on current dollar values.

(c) The postulated accident is described in References (8) and (9). It relates to the hypothetical crashing of a 747 aircraft into Hollywood Park Race Track (near Los Angeles International Airport), while the race track is crowded. To express this risk in a "probability per year" figure, one has to multiply the 1×10^{-5} per site per year by the number of potentially high-consequence sites near large airports. Approximately 5×10^{-3} to 1×10^{-3} events of similar catastrophic magnitude per year can be expected.

(d) The hypothetical risk refers to a postulated chlorine spill in the vicinity of a large population center. This risk is estimated from information contained in References (10,11,12). To relate this "per site per year" probability to a "per year" probability, we have to multiply by the number of potentially-high-consequence sites. Considering all potentially hazardous chemicals, up to 25,000 fatalities can be expected due to a single event, with a probability of about 1×10^{-5} per year in the United States. (Data derived from (12)).

(e) The consequence of this hypothetical dam failure is based on information in References (13,14). The probability is obtained from Reference (15). Again, this probability is normalized to "per site".

(f) There is no record of large numbers of fatalities due to drug toxicity, but injuries and diseases have developed.

(g) In the past 1000 years there has been approximately 3 million deaths around the world due to large earthquakes. (The major portion of these fatalities occurred when the population density was much lower than today.) About 1.5 million deaths resulted from only five earthquakes, and about 0.8 million deaths were due to only one earthquake. Based on this history, 100,000 to 1,000,000 fatalities can be exptected from earthquakes with a probability range of 1×10^{-3} to 1×10^{-4} per year. This projection is confirmed by information contained in Reference (16).

(h) The hypothetical scenario that takes 1,500 to 3,000 lives with a probability of 1×10^{-6} per year per high-risk site refers to a massive fire in a large hotel at night, or to a massive fire in a large office building during working hours. Unless the fire spread to other structures, the expected mortalities would not be more than 1,500 to 3,000 per high risk site. There may be 1,000 such high-risk sites in the U.S.

(i) In the past 100 years about 1.5 million people died as the result of major floods (in this study a major flood is defined as one that results in 100 or more mortalities (16). Based on this information, floods can claim the lives of 200,000 to 1,000,000 people every 100 years.

(j) There have been no known mortalities due to meteorite impacts (17,18). However, based on data in References (17,18,19), a large enough meteorite impact could result in 10,000 fatalities once in every 10 million years.

(k) The largest single mine disaster killed 361 people (10). Since not more than 500 to 1,000 people are expected to be in a mine at any single time, that would be the maximum number of mortalities per disaster. This event could occur with a frequency of 1×10^{-2} to 1×10^{-3} per year (this probability range is based on data in Reference (10)).

The Federal Black Lung Benefits Program has paid an average of $1 billion per year over the past several years to victims of black lung disease. According to Arnold Miller, president of the United Mine Workers, more than 11 men per day die prematurely as a result of black lung disease (20). According to him, this event occurs with a probability of about 1 to 4,000 people per year with an approximate liability of $1 billion per year (or about $250,000 per premature fatality).

(l) Reference (19) estimates the risk due to the MCA involving a 1000 MWe light water reactor at an "average site". Based on a yet unpublished study by one of the authors of this report, the risk for the MCA for reactors located downwind from a large population center is under-estimated. In fact, under some circumstances, the probability of having 10,000 to 20,000 mortalities at a single "very high risk site" might be as high as 1×10^{-7} per year (19) It should be noted that some nuclear reactor sites have lower-than-average population centers downwind, and hence the risk would be significantly lower.

(m) The collision of two passenger ships and their subsequent sinking could result in about 5,000 fatalities. In this study we postulated the collision of a large LNG Tanker and a large passenger ship, involving the subsequent explosion of the tanker, the sinking of both ships, and the loss of all lives on both ships (perhaps 2,500 to 3,000 fatalities). Based on data in Reference (21), the estimated probability of this event is in the order of 1×10^{-6} to 1×10^{-7} per year.

(n) During the period 1963 to 1965, approximately 79,000 drownings resulted from tidal waves and/or hurricanes in East Pakistan (13). Based on the frequency and magnitude of historic tidal waves and hurricanes, 50,000 to 500,000 fatalities could occur in a specific region within a few years with a probability of 1×10^{-2} to 1×10^{-3} per year (16,22).

(o) Reference (16) lists all major tornadoes in the United States in the past 100 years and the associated number of fatalities. Based on this information, 1,000 to 10,000 fatalities could occur as the result of a single tornado (or a series of tornadoes within a region) with a probability of about 1×10^{-2} to 1×10^{-3} per year.

(p) A passenger train is not likely to carry more than 500 to 1000 passengers. The collision of two trains could result in up to 2000 fatalities. Based on the frequency of past train crashes, the probability of having 200 to 2000 fatalities is likely to be between 1×10^{-1} and 1×10^{-2} (16).

(q) We are assuming that Workmen's Compensation laws do not limit liability.

The values given here reflect a wide range in history, varying from thousands of years for earthquakes to tens of years for nuclear reactors and modern drugs.

Because the postulated events are intended to be "order of magnitude" maximum-type accidents, the associated probabilities are lower than other, smaller, accidents of higher probability.

The liabilities are estimated based on the expected consequences of the "maximum" event. Probabilities (sometimes crudely guessed) of these events are also listed.

Based on the assumptions of this study, floods, due to river overflow, dam failure, or a combination of the two, would result in maximum liabilities. The proposed Auburn dam, to be located in Northern California, with 4,200 feet width and 700 feet height is one example. Northern California is prone to earthquakes; according to the U.S. Geological Survey scientists, there is a dangerous earthquake fault less than a mile away from the proposed dam site. The Association of Engineering Geologists warned last year that an earthquake could shatter the dam, releasing a 40 mile-long reservoir containing 736 billion gallons of water. As a result, a sudden complete dam failure is estimated to release a 100 foot high wall of water that could rupture other dams downstream. At a Federal Hearing on this project in March 1977, Civil Engineer Harry Cedergren said that the collapse of the Auburn Dam could "kill up to 1 million people, flood 1,000 square miles of

developed land, inundate five military installations and cause \$40 or \$50 billion in property damage." If one were to assume that the liability associated with each fatality is \$1 million, (an arbitrary assignment, but one in general agreement with other sources[4], then 1 million fatalities plus the property damage could result in a liability of one trillion and fifty billion dollars (i.e., $\$1.050 \times 10^{12}$).* This potential damage is equal to over half of the current gross national product of the U.S., or roughly to the sum of the gross national products of Canada, France, the United Kingdom, and West Germany.

Although a single earthquake in the past has caused nearly a million deaths,[24] and future earthquakes could cause similar, or larger number of fatalities, it would be difficult to assign a corresponding liability. Such an earthquake, also, might lead to the failure of large structures which were seismically deficient.

Other natural events, e.g., tidal waves, hurricanes, tornadoes, and meteorite impacts could also cause large numbers of fatalities, but would not result in assignable liabilities.

A variety of technological events could result in assignable losses of up to \$25 billion, or more, depending on the value of life. These postulated events include:

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*With a value of life at $\$2 \times 10^5$, the liability would be \$250 billion.

(1) The crash of a large aircraft into a crowded sports facility (an estimated $20.3 billion liability);

(2) An explosion and subsequent dispersion of a chemical (such as chlorine or LNG) into a population center from a large manufacturing, storage, or transport facility (estimated $25.5 billion liability);

(3) The mass consumption of a drug that contains toxic material, thus resulting in large numbers of deaths (liability up to $50 to $100 billion, corresponding to 50,000 to 100,000 fatalities)*;

(4) A massive fire in a large, crowded building, such as a skyscraper, or a hotel whose elevators fail due to the fire (up to $3.2 billion liability);

(5) A catastrophic mine disaster or the liability associated with premature deaths such as asbestos-induced cancer or black lung disease ($1 billion liability);

(6) A massive nuclear power plant accident and the subsequent dispersal of large quantities of radioactive material to a large downwind population center ($25 billion liability);

(7) The collision of two ships, such as a large LNG tanker and a large passenger liner, resulting in the deaths of all passengers on board ($5.5 billion liability);

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*This scenario is very unlikely, but could be caused by drugs that are consumed by a large portion of the population before their harmful effect is established. It is possible to postulate such an accident for drugs with undetected delayed effects.

(8) A head-on collision of two large passenger trains, resulting in the death of most, or all passengers; and

(9) Collapse of a large building in an earthquake, known by the owners to be seismically deficient and no steps having been taken to warn occupants or to remedy the situation (major deficiencies).

Assigning Liability

Table 2 lists the potentially liable parties for the accident scenarios previously described. Because liability can only be established by the courts (or by a waiver of defenses as under the Price-Anderson Act) these assignments are judgmental - they do not represent a review of legal precedents. As indicated, following any accident or event which is likely to result in losses borne directly by the victims, government aid may be given to compensate these victims; there is no legal requirement that requires the government to provide this aid.

Compensation of the Public - Is the Public Fully Protected?

As was discussed earlier, a nuclear power accident which caused damages exceeding $560 million would result in less than full compensation of accident victims (unless a Congressional appropriation were made). Under these other accident scenarios, the liability is not limited by law. Our interest in this topic is more pragmatic; what compensation can actually be collected by the public following a high-consequence accident?

TABLE 2: POTENTIALLY LIABLE PARTIES FOR HIGH-CONSEQUENCE RISKS

EVENT AND/OR ACCIDENT SCENARIO	LIKELY LIABLE PARTY					
	GOVERNMENT			CORPORATION		PRIVATE
	FEDERAL**	STATE	CITY, COUNTY, MUNICIPALITY	LARGE	SMALL	INDIVIDUAL
AIRCRAFT CRASH			POSSIBLE	PROBABLE	PROBABLE	
CHEMICAL PLANT FIRE				PROBABLE	PROBABLE	
DAM RUPTURE	PROBABLE	PROBABLE	PROBABLE	PROBABLE	POSSIBLE	
DRUG TOXICITY	POSSIBLE			PROBABLE	PROBABLE	
EARTHQUAKE	*	*	*	POSSIBLE	POSSIBLE	POSSIBLE
FIRE	POSSIBLE	POSSIBLE	POSSIBLE	POSSIBLE	POSSIBLE	POSSIBLE
FLOOD	*	*				
METEORITE IMPACT	*					
MINE DISASTER	POSSIBLE	POSSIBLE		POSSIBLE	POSSIBLE	
NUCLEAR REACTOR ACCIDENT	PROBABLE			PROBABLE		
SHIP DISASTER	POSSIBLE			PROBABLE	PROBABLE	
TIDAL WAVE/HURRICANE	*	*				
TORNADO	*	*				
TRAIN CRASH			POSSIBLE	PROBABLE	PROBABLE	

*Rather than liability, it is most likely that aid from governmental bodies is involved for such "natural events."

**Under many of these scenerios federal liability may be established, however, this can only occur if governmental permission to sue is first granted. Federal disaster relief may also be appropriated for any serious accident, regardless of cause or of the liability of others.

The first layer of protection for the public is the insurance carried by those potentially liable for large accidents. Most large companies buy \$25-\$50 million policies, although a few larger policies have been written (see Table 3).

Each of these policies involves a large number of insurance companies because no one company will provide such vast coverage. Dispersion of policies results from the insurance industry's preference for distributed risk (i.e., an insurance company would rather sell a large number of small policies than a few large policies). In addition, state regulations usually limit the liability on each policy to a small percentage of an insurance company's assets. Because the total coverage offered by a pool of insurance companies is the sum of the coverages provided by the individual members, these same state regulations serve to set an upper limit on the total amount of insurance that can be sold to cover any one risk. (The coverage for each nuclear plant is among the largest offered by the insurance industry.)

Beyond this insurance coverage are the assets of the liable parties. Table 4[23] contains the assets of selected companies in a variety of industries. These companies were chosen randomly within the industry. It is not implied that any of these companies is more or less likely to be held liable for damages as a result of consumer use of their products or services.

TABLE 3: LARGE INSURANCE POLICIES, SELECTED EXAMPLES

INSTITUTION	LIABILITY INSURANCE CARRIED
State of California	$50 million (dams, aircraft)
City of San Francisco	$50 million (dams)
University of California	$50 million (medical facilities, athletic stadiums)
Standard Oil of California	$100 million (refineries, storage tanks for oil and gasoline)
Pacific Southwest Airlines	$100 million
Pan American World Airways	$200-$250 million
Los Angeles Department of Water and Power	$100 million

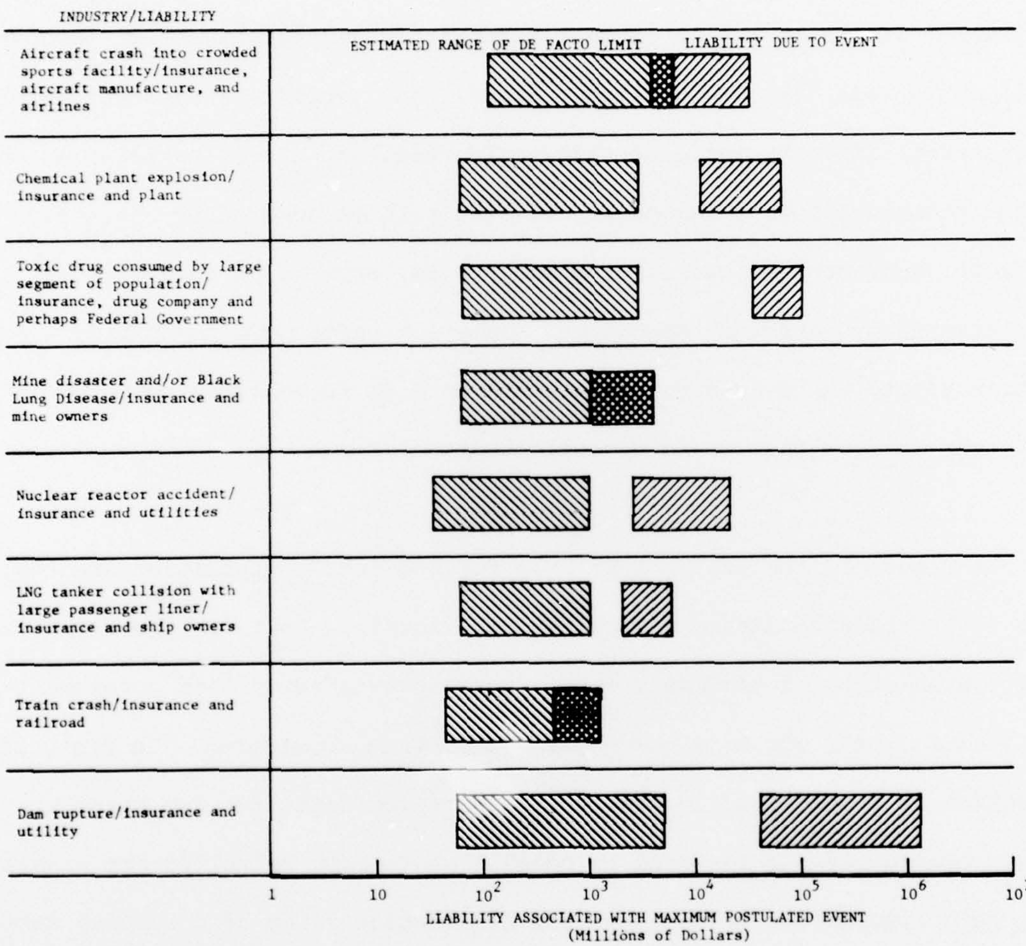
TABLE 4 : ASSETS OF SELECTED LARGE COMPANIES AND BUDGETS OR GNP's OF SELECTED GOVERNMENTS[23]

INDUSTRY / COMPANY	Cash and Current Equivalent Assets ($ Billion)	Current Liabilities ($ Billion)
AIRLINES & AIRCRAFT MANUFACTURERS		
• BOEING CO.	1.546	0.527
• LOCKHEED AIRCRAFT	0.887	0.646
• AMERICAN AIRLINES	0.939	0.454
• PAN AM WORLD AIRWAYS	0.630	0.359
• PSA	0.068	0.021
CHEMICAL COMPANIES		
• ALLIED CHEMICAL	0.759	0.335
• DOW CHEMICAL	2.563	1.568
OIL COMPANIES		
• SHELL	3.110	1.573
• STANDARD OIL OF CALIFORNIA	6.561	4.385
DRUG COMPANIES		
• MORTON-NORWICH PRODUCTS	0.228	0.064
• UPJOHN CO.	0.519	0.160
INSURANCE COMPANIES		
• FARMER'S GROUP	0.101	0.018
• MANHATTAN LIFE	4.907 (Ins. in Force)	—
• PRICE-ANDERSON ACT		—
• PRUDENTIAL OF AMERICA	91.120 (Ins. in Force)	
LNG SHIPPER/SHIP BUILDER		
• AMERICAN SHIPBUILDERS	0.057	0.018
• EL PASO GAS CO.	0.540	0.303
RAILROADS		
• MISSOURI PACIFIC RAILROAD	0.232	0.203
• SANTA FE RAILROAD	0.248	0.148
UTILITIES		
• PORTLAND GENERAL ELECTRIC	0.073	0.132
• SOUTHERN CALIF. EDISON	0.534	0.445
GOVERNMENTS		
• LOS ANGELES (CITY)	About $1 Billion Dollar Annual Budget	
• GREAT BRITAIN	GNP of $174 Billion in 1974	
• UNITED STATES	GNP of $1,281 Billion in 1974	
• WEST GERMANY	GNP of $349 Billion in 1974	

For illustrative purposes, let us initially examine the aircraft manufacturing and airline industries. Let us assume a hypothetical event with 20,000 mortalities as the result of an aircraft crash into a crowded sports facility.[8] The total liability of this postulated event may exceed \$20 billion. The gross equivalent assets of any one airline and all but one aircraft manufacturer is less than \$1 billion. Even the combined gross equivalent assets of the 10 largest aircraft manufacturers and 20 largest airlines is less than \$20 billion. Hence, the liability associated with a hypothetical aircraft accident that would result in 20,000 mortalities and in the related property damage is not likely to be covered by the assets of aircraft manufacturers and airline industries, even if those assets were supplemented by insurance companies. Unless a large government body also contributes to these assets, there would be a *de facto* limit on recovery (i.e. the damages that could be collected).

In Figure 1, the monies available for accident compensation are compared with the postulated damages calculated previously. As this figure indicates, full compensation of claimants is not possible without direct government aid for virtually all the high consequence accidents considered. In fact, the situation is probably worse than this figure indicates for two reasons. First, company assets (as used to compute stock book value) do not usually represent liquidation value; but the liquidation value of a company determines its maximum ability to pay damages. Second, these asset evaluations represent the worth before a major accident, but the assets after an accident will

FIGURE 1: DE FACTO LIMITATIONS ON LIABILITY RECOVERY FOR MAXIMUM POSTULATED EVENTS IN SELECTED INDUSTRIES (ILLUSTRATIVE DATA)



likely be less than before. For example, any nuclear power plant accident causing substantial public damage will result in the total and permanent loss of the power plant itself. Under these circumstances, a utility faces a loss that would be approximately $800 million (roughly the plant of a billion dollars value minus the insurance for the plant loss, typically $175 million). The utility also faces replacement power costs of approximately $200,000 per day. This ignores the more problematic issue of how to liquidate utility assets.

Lest we give the impression that the problem of receiving full compensation is unique to big business and government, we wish to point out that limits on the ability to pay damages occurs at relatively low loss levels. For example, the required liability insurance for automobile drivers is $25,000 in many states; yet a driver found liable for accidents causing multiple fatalities may face a payment in the millions of dollars. Additionally, for those cases in which federal government aid is provided, less than full compensation may result. In the case of the June 5, 1976 collapse of the Teton Dam (built by the Bureau of Reclamation) the initial damage estimates ran as high as a billion dollars; ten days after the accident the house appropriated $200 million in aid.(25) (More recent analysis has placed the damage at roughly $400 million not counting the loss of the dam. As of January 1977 direct federal expenditures including loans totaled $210 million.(26))

Other Factors in Public Protection

Safety Incentives

It has been argued that the insurance procedures proscribed by the Price-Anderson Act fail to provide adequate safety incentives to utilities operating reactors.(3) While this is true, we believe it is irrelevant for

several reasons. First, Price-Anderson was never intended to provide such incentives. Second, there are other incentives for nuclear power plant safety which we believe far exceed those that would occur if the insurance we sold under perfect market conditions, and third, even in the absence of Price-Anderson it is unlikely that perfect market conditions would be achieved for nuclear power plants because the lack of data (due to the lack of accidents) would prevent the determination of actuarially fair premiums.

To understand the other more significant incentives, an appreciation of the statistical nature of plant failures and accidents is required. Any risk is defined by its associated probability and consequences. For virtually all risks, a nearly continuous spectrum of possible consequences exists, and as the consequences become higher, the probabilities become lower. In a nuclear power plant, the types of failures range from minor component failures which can be repaired during plant operation, through failures that cause shutdowns of increasing duration, to those that threaten permanent loss of the plant. Beyond these events are the accidents which threaten public health and safety. Considering replacement power costs and new plant costs, the exclusion of accidents that might cause in excess of $140 million (the private insurance limit) does little to change the expected cost of all accidents (where the expected cost of all accidents is the product of probability and loss for a particular accident, summed over all possible accidents). Additional safety incentives are due to the NRC policy

of fining reactor owners for violations of proper operating procedures. Finally, there are the incentives for plant operations and maintenance personnel that arise from their concern for their own personal safety. These people are at the highest risk (much higher than the general public), and have clear incentives to see that the plant operates safely.

In comparison to non-nuclear facilities, the insurance premiums for nuclear plant liability do offer additional incentives, and as we have shown, the insurance in force is generally in excess of that carried by these other facilities. The additional incentive, reflected in the premium, is due to the waiver of defenses for all causes. Because the utility will be liable even if an accident is caused by an earthquake or a faulty component supplied by an outside manufacturer, a degree of certainty is found that is not present for other facilities.

Procedures for Collecting Damages

In the event of a nuclear accident, the insurance pools would send representatives to provide immediate relief funds. These funds would not constitute a settlement, as the relief is provided without obtaining a legal release. Thus, an individual who suffered damages would receive money to provide immediate expenses and repairs, yet would have time to assess the full damages before accepting a settlement.

The collapse of the Baldwin Hills Dam in Los Angeles in December 1963 provides an unfortunate counterexample. Following the collapse, the companies insuring the Los Angeles Department of Water and Power refused liability on the grounds that the collapse was due at least partially to oil and gas drilling in the area. Their claim was that the removal of oil and gas softened the soil under the reservoir. The oil companies operating the wells denied responsibility. During the time of this dispute, no claims were paid. Finally, the state passed emergency legislation requiring the insurance companies to pay the damages and seek compensation from the oil companies in court. The insurance companies paid about $15 million and eventually recovered about $3 million from the oil companies.

This example points out the difficulties faced by accident victims. At a time when they have suffered a loss, the claimants may be faced with mounting a legal suit against a company with greater legal resources and little incentive to seek a rapid settlement. The further requirement that the claimant prove that the company is at fault can add to these difficulties, particularly when there are extremely complex and technical issues involved in establishing fault (as was the case in the above example).

There is also the situation in which the facility causing the public damage represents the total assets of a company - when the accident occurs no assets are left to pursue. This situation offers the ownership little if any incentive for carrying liability insurance. Examples of this are reportedly common in the shipping industry, where various holding companies, each owning one ship, provide liability protection for a parent company.

Conclusions

Limits, statutory or de facto, exist for the amount of damages that can be collected following an accident. We expect, although we did not prove, that in all cases in which liability insurance is carried, an accident may be postulated which would exceed the available insurance and assets of the liable party. For this reason we believe that the complaint that Price-Anderson type insurance does not fully protect the public is irrelevent - no insurance method now in use fully protects the public.

While this clearly is not a desirable situation, we do not see more attractive alternatives readily available. The assets and carrying capacity of the private insurance industry is limited, and as a result the maximum liability insurance available for a single event is limited (in fact to a small percentage of this capacity). The desirability of extending government insurance beyond its present areas (nuclear power, floods, crop loss for example) is an issue beyond the scope of this paper. Regardless of what approaches are taken in the future, we hope that the impact of the mechanisms upon the individual claimant are considered in a realistic way; this is one area in which the Price-Anderson Act is clearly preferable.

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